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Diet of the western grey kangaroo (*Macropus fuliginosus* Desm.) in a mixed pasture-woodland habitat of Western Australia

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Abstract

The late autumn/early winter diet of western grey kangaroo living in a landscape of native wandoo open forest surrounded by pasture grasslands was assessed using faecal analysis. Eventhough some animals were observed regularly feeding in the pastures at night, a considerable number of native woodland species appeared in their diet in addition to the exotic pasture species. Thirty-one taxa of native plants were recorded from grey-kangaroo faeces. Of the native species, *Conostylis setigera, Opercularia vaginata, Bossiaea eriocarpa* and *Casuarina* spp. were the most frequently encountered in the faecal preparations. The frequency of pasture grasses appearing in the faecal material increased following the first winter rains which resulted in good pasture growth. Apparently kangaroos travel considerable distances to graze or browse on favoured species. Higher nitrogen content of certain favoured native species is hypothesized as contributing to this preference.

Introduction

European settlement of Australia has had a profound effect on the members of the Macropodidae. Some species have been driven to extinction, while others have increased in numbers due to favourable habitat changes (Calaby 1971). Changes in vegetation due to grazing stock have generally improved the habitat for the red kangaroo (*Megaleia rufa* Desm.) in many parts of its range and populations have greatly increased in numbers (Frith 1964, Newsome 1965). The western grey kangaroo (*Macropus fuliginosus* Desm.) and eastern grey kangaroo (*Macropus giganteus* Shaw) have disappeared from heavily settled areas but their numbers can be high in some pastoral districts.

At present the large macropods are variously viewed as pests whose population size should be controlled, objects of aesthetic pleasure and should be protected, or a valuable wildlife resource worthy of exploitation and conservation. Each of these views requires the development of a suitable management programme. To accomplish the aims of any management programme, there must be some manipulation of the environment or the animal population (Main 1968). The first step in the research programme to establish a management plan data base is to understand the relationship between the organism and its environment. Social organisation, habitat choice, food habits and the ecophysiology of the organisms are just some of the areas which need to be considered.

The ecology of a resident population of western grey kangaroo in a mixed landscape of native woodland and pastoral lands on the CSIRO Yalanbee Experimental Station at Bakers Hill, Western Australia is currently being studied (G. Arnold, pers. comm).

The grey kangaroos at the Yalanbee Experiment Station spend much of the day in a 90 ha area of native woodland. Spotlighting and a system of camera and electric-eye monitored fence openings indicate that numerous kangaroos feed in the pasture lands adjacent to the native woodland (G. Arnold, unpublished data). However, little is known of their feeding behaviour in the native woodland area. Objectives of this current study were to document the natural vegetation of the grey kangaroo residence area at the Yalanbee Experiment Station and to determine information on the kinds of food resources the animals are exploiting.

Study site

The Yalanbee Experiment Station at Bakers Hill, Western Australia (31°45'S, 116°27'E) lies 90 km north-east of Perth and 26 km south-east of Northam. The climate is Mediterranean with mild wet winters and hot dry summers. Twenty year averages from the station indicate a mean annual precipitation of 625 mm, with the highest mean monthly values occurring in June and July, both at 86 mm. Average maximum temperatures range from 17°C to 34°C in July and January, respectively. Summer daily maxima over 40°C are common. Mean monthly minima range from 17°C in January to 4°C in July.

Topographic relief of the study area is low, with a range of approximately 150 m (Fig. 1a). Soils in the study area include the Yalanbee, Kauring and Malebelling soil series (Fig. 1b). Yalanbee soils ocupy the highest landscape positions and are predominantly yellowish-brown ironstone gravels. Kauring soils are shallow, overlying granitic rocks which are exposed in some areas. Malebelling soils consist of light-brown gritty loamy sand with some ironstone gravels toward the base over yellow and reddish-brown mottled sandy-clay loam with rock fragments.

Vegetation

The Yalanbee Experiment Station lies within the Wandoo Woodland vegetational region (Gardner 1942). The regional dominant is *Eucalyptus wandoo*. Depending on habitat conditions, *E. accedens*, *E. marginata*, *E. calophylla* and *Casuarina huegeliana* can also be common species of the woodland canopy stratum. Ground traverses provided a subjective impression of the vegetation of the native woodland at the station and helped locate representative stands for intensive sampling.

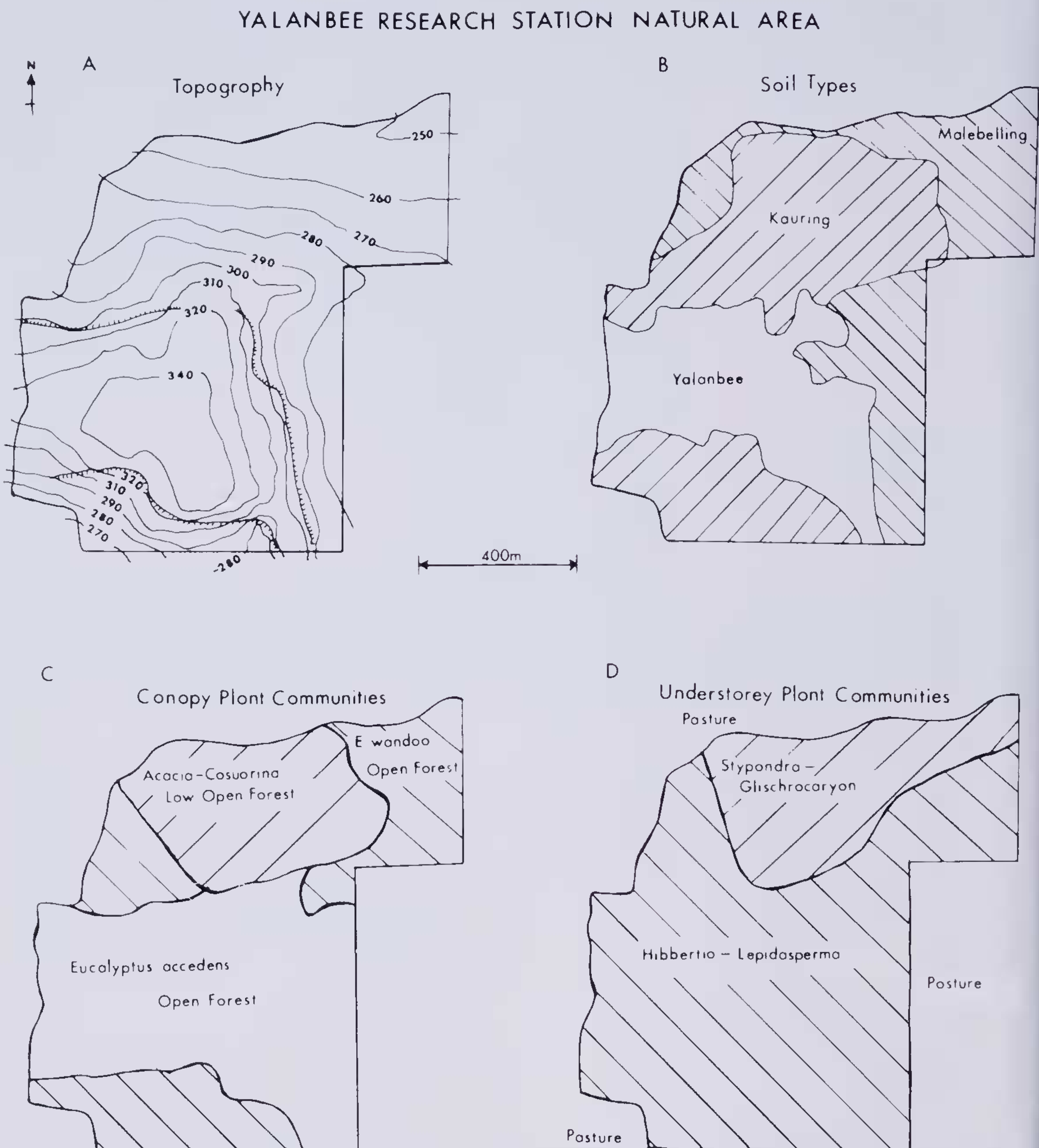

Figure 1.—Yalanbee Research Station Natural Area. (A) Topography shown by 5 m elevational contours. Breakaway slope margin is also shown. (B) Soil types of the study area after Dimmoch (unpublished data). (C) Canopy vegetational communities. (D) Understorey vegetation communities.

The tree stratum was sampled using 23 sites of 10 x 10 m. Within each site all trees (diameter at breast height (dbh) > 4 cm; height > 2 m) were identified to species and the dbh measured. A canopy density value for the site was obtained as the mean of four readings on a crown-cover densiometer (Lemmon 1956). The mean of the relative density and relative basal area provided species importance values for the primary stand by species data matrix.

The understorey stratum was sampled at 25 sites distributed throughout the natural woodland area. At each site a line transect of sixteen 1 m^2 quadrats provided an estimate of species cover and frequency. An understorey importance value for each species was calculated by summing the mean cover and frequency percentages and dividing by two. The vegetation data was subjected to several ordination techniques using the Ordiflex Program Package of Gauch (1973) and a polythetic agglomerative classification system (Gilbert and Walls 1966) using percentage similarity (Bray and Curtis 1957). Mapping divisions were constructed objectively from the results of the data analysis. By locating the sites on aerial photographs and using apparent photographic similarity, physiognomic features, geomorphological data and further field observation, the vegetation maps were developed. The canopy plant communities were named for the dominant species and the structural classifications of Specht (1970). Understorey plant communities were named for their most important species, even though the two species were only a part of very diverse assemblages of species.

Canopy Communities

The three communities designated were 1) Powderbark (*Eucalyptus accedens*) open forest, 2) Wandoo (*E. wandoo*) open forest, and 3) *Acacia-Casuarina* (*Acacia acuminata-Casuarina huegeliana*) low open forest (Fig. 1c). The Powderbark open forest was dominated by *E. accedens* and occurred on the old lateritic plateau and the eastern break-away slope. Other tree species in the community were *Dryandra sessilis, E. wandoo, E. marginata* and *E. calophylla. D. sessilis and E. marginata* were restricted to areas of the lateritic plateau. The average canopy cover of the community was 38% and the mean height of the trees was 42 m.

The Wandoo open forest community named for the dominant species, *E. wandoo,* was found in three areas of the native vegetation. These occurred on the southern steep break-away slopes, the north-eastern more gradual slopes and the nearly flat north-western corner region. Other occasional associates of *E. wandoo* in this community were *Acacia acuminata, E. calophylla, C. huegeliana* and *E. accedens.* Canopy cover averaged 46% and the mean height of the trees was 39 m.

The *Acacia-Casuarina* low open forest was co-dominated by *Acacia acuminata* and *Casuarina huegeliana.* The community was confined to the northern slopes and restricted to the soils which were shallow and overlying granitic parent material. Other tree species in the community were *E. accedens, E. calophylla* and *E. wandoo.* Mean canopy cover was 33%, but the range of between 5% and nearly 100% gives a better representation of the discontinuous nature of the distribution of thickets of *Acacia* and *Casuarina.* Average tree height was 7 m.

Understorey Communities

Unlike the separation into three apparent communities found in the canopy, only two distinct types of understorey were delineated in the analysis of the data from the understorey vegetation sampling data. The extreme heterogeneity of the understorey vegetation presented difficulties and even the samples within the same major group have only limited similarity. The two very broad classification groups were designated as the *Hibbertia-Lepidosperma* community, and the *Stypandra-Glischrocaryon* community.

The *Hibbertia-Lepidosperma* community covered the majority of the area except the north-central region (Fig. 1d). *Hibbertia hypericoides, Lepidosperma tenue, L. scabrum,* and *Conostylis setigera* were common throughout the area (Table 1). *Hakea lissocarpa, Acacia celastrifolia, Calothamnus sanguineus, Adenanthos cygnorum* and *Gastrolobium trilobium* were dominants in restricted areas of the community. The understorey layer generally ranged from 0.5 m to 1.5 m in height. Percentage cover ranged from areas almost denuded of understorey species on the break-away slopes to 75% in areas on the lateritic plateau.

The *Stypandra-Glischrocaryon* community was restricted to soils of granitic origin within the areas of *Acacia-Casuarina low open forest. Stypandra imbricata* and *Glischrocaryon aureum* were common through this region (Table 1). Other common species were *Opercularia vaginata, Trymalium ledifolium, Scaevola fasciculata, Xanthorrhoea preissii* and *Neurachne alopecureoidea.* The shrub height rarely exceeded 1 m except for the occasional *X. preissii.* Presenting the data for the two understorey communities as mean cover values and frequency percentages (Table 1) provides information on plants available to the grey kangaroo for food.

Kangaroo diet

Spot-lighting surveys reveal that grey kangaroo at the Yalanbee Experiment Station do feed in the pastoral areas adjacent to the native woodland (G. Arnold, unpublished data). These survey techniques cannot be used effectively, however, to observe the animals feeding in the heavy scrub of the native bushland areas. An important aspect of the current study was to discover what plants the grey kangaroo utilized in their diets and to determine if the diet changed markedly when the winter rains made green feed more readily available. As the population dynamics of the group were also under study, direct analysis of rumen contents of culled animals was not possible. Indirect methods using identification of faecal pellet plant fragments and records of grazed plant species provided the best alternatives.

Table 1

Mean percentage cover values and frequency percentages for species determined from the sites classified into the *Stypandra-Glischrocaryon* and *Hibbertia-Lepidosperma* communities. Abbreviations are: for Order, Monocotyledonae (M) and Dicotyledonae (D); and for Life Form, Shrub (S), and Herbaceous Perennial (H). All non-legume species found in less than 3% of quadrats grouped as "minor" species.

Species	Order	Family	Life Form	*Stypandra-Glischrocaryon* Cover	*Stypandra-Glischrocaryon* Freq.	*Hibbertia-Lepidosperma* Cover	*Hibbertia-Lepidosperma* Freq.
Stypandra imbricata	M	Liliaceae	S	3·20	47·5		
Glischrocaryon aurea	D	Haloragaceae	S	2·50	41·2	0·11	3·4
Scaevola fasciculata	D	Goodeniaceae	S	3·00	40·0		
Neurachne alopecuroides	M	Poaceae	H	1·10	57·5	0·57	20·0
Phyllanthus calycinus	D	Euphorbiaceae	S	0·60	31·4	0·56	13·8
Trymalium ledifolium	D	Rhamnaceae	S	6·40	31·3	0·47	4·0
Opercularia vaginata	D	Rubiaceae	H	2·30	25·0	0·31	4·7
Stackhousia pubescens	D	Stackhousiaceae	S	0·40	18·8		
Bossiaea eriocarpa	D	Papilionaceae	S	0·80	16·2	0·38	10·6
Anthocercis littorea	D	Solanaceae	S	1·30	11·2		
Lomandra caespitosa	M	Liliaceae	S	0·20	10·0	0·06	5·9
Acacia acuminata	D	Mimosaceae	S	0·38	3·8		
Gompholobium preissii	D	Papilionaceae	S	0·06	6·2	0·09	3·8
Xanthorrhoea preissii	M	Liliaceae	S	0·20	1·2	1·36	5·3
Lomandra hermaphrodita	M	Liliaceae	H	0·06	1·2	0·14	5·9
3 Minor Dicot spp.	D		....	0·06	...		
26 Minor Dicot spp.	D		...	...	....	2·75	..
8 Minor Monocot spp.	M		...	....	....	0·28	
Adenanthos cygnorum	D	Proteaceae	S	....	....	0·69	3·0
Hakea ruscifolia	D	Proteaceae	S	....	....	0·48	3·1
Lepidosperma angustatum	M	Cyperaceae	H	....	....	0·11	3·4
Trymalium angustifolium	D	Rhamnaceae	S	....	....	0·56	3·6
Stylidium brunoneanum	D	Stylidiaceae	H	....	....	0·06	3·8
Baeckea camphorosmae	D	Myrtaceae	S	....	....	0·30	3·8
Hakea ambigua	D	Proteaceae	S	....	....	0·83	3·8
Dryandra sessilis	D	Proteaceae	S	....	....	0·54	3·8
Dryandra carduacea	D	Proteaceae	S	....	....	1·18	4·1
Acacia celastrifolia	D	Mimosaceae	S	....	....	0·72	4·7
Casuarina humilis	D	Casuarinaceae	S	....	....	0·83	4·7
Hakea incrassata	D	Proteaceae	S	....	....	0·55	5·0
Lasiopetalum molle	D	Sterculiaceae	S	....	....	0·13	5·3
Borya nitida	M	Liliaceae	S	....	....	0·78	5·3
Gastrolobium trilobum	D	Papilionaceae	S	....	....	2·02	5·6
Petrophile striata	D	Proteaceae	S	....	....	1·23	6·6
Hakea undulatum	D	Proteaceae	S	....	....	0·63	6·3
Lepidobolus sp.	M	Restionaceae	H	....	....	0·92	6·6
Leptospermum erubescens	D	Cyperaceae	H	....	....	0·85	6·9
Tetraria octandra	M	Cyperaceae	H	....	....	0·57	7·2
Calothamnus sanguineus	D	Myrtaceae	S	....	....	2·22	7·8
Dampiera lavandulacea	D	Goodeniaceae	S	....	....	0·19	8·4
Dryandra nivea	D	Proteaceae	S	....	....	1·04	8·7
Acacia pulchella	D	Mimosaceae	S	....	....	0·53	9·1
Melaleuca holosericea	D	Myrtaceae	S	....	...	2·53	9·7
Hakea trifurcata	D	Proteaceae	S	....	....	2·74	10·0
Calytrix brachyphylla	D	Myrtaceae	S	....	....	0·65	12·8
Lepidosperma tenue	M	Cyperaceae	H	....	....	0·63	14·7
Hibbertia montana	D	Dilleniaceae	S	0·25	3·8	0·78	15·9
Jacksonia restioides	D	Papilionaceae	S	....	....	1·42	15·6
Hemigenia canescens	D	Lamiaceae	S	....	..	1·16	15·6
Loxocarya flexuosa	M	Restionaceae	H	0·71	7·5	1·71	20·0
Hakea lissocarpha	D	Proteaceae	S	....	....	2·90	21·6
Lepidosperma scabrum	M	Cyperaceae	H	0·06	1·2	1·19	21·8
Conostylis setigera	M	Haemodoraceae	S	0·10	6·2	1·52	34·1
Hibbertia hypericoides	D	Dilleniaceae	S	....	....	5·72	48·1

The epidermis of leaves has a number of characteristics which are useful in the identification and classification of plant species. They also have the advantage that most of the cuticular and epidermal tissue remain undigested in the passage through the digestive systems of animals. Cuticular material can also be identified in animal stomach contents and faeces, (Stewart 1967, 1971, Stewart and Stewart 1970). No study of epidermal characteristics of species of the Wandoo Woodland, however, was available for identifying epidermal fragments in the faecal pellets of the grey kangaroo. An initial period was, therefore, necessary to prepare a series of reference slides of epidermal material from plants known from the woodland and pasture areas of the Yalanbee Experiment Station (Halford *et al.* 1984.)

Epidermis Reference Collection

Reference slides of suitable quality were produced of 60 of the 140 species identified in the native vegetation area and adjacent pasture using the techniques of Storr (1961) and Jain (1976). The relative merits of each of these techniques are discussed in a previous paper (Halford *et al.* 1984). In those species which have leaves or phyllodes which are reduced or absent, the epidermal features of stem material were used for descriptive purposes. Also in a few cases there was some difficulty in finding sufficient species-specific epidermal characters to differentiate members within one genera. There was, however, little difficulty in separating generic groups on the basis of epidermal characters alone.

Faecal Material Preparation

Microscopic observation of the untreated faecal material did not provide sufficient clarity of the epidermal fragments for identification. A modification of Storr's (1961) preparation was, therefore, used to clear epidermal material from residual fibre fragments. Such acid digestion procedures have presented problems in animal diet analyses previously (e.g. Griffths and Barker 1966) but it was felt that the ability to identify plant species in the faecal pellet was enhanced to a far greater extent than the potential to lose species from the dietary list due to complete digestion of soft epidermal tissue by this method. Each faecal pellet was split into two equal portions. One portion was stored to allow for possible re-analysis. The other portion was placed in a 20 ml solution of equal parts of 10% chromic acid and 10% nitric acid and gently boiled for 15 min. After maceration, the material was allowed to cool, rinsed with a very dilute solution of KOH. The material was then suspended in a 0.5% solution of gentian violet in 95% alcohol. After staining for 48 h, the material was passed through a 0.5 mm sieve and both the fractions resuspended. Samples of each were placed on microscope slides and mounted in euparal. The separation of these fractions generally assisted in the visual clarity of the slides. The slides were examined at a magnification of 70 x. All fragments lying in the field of view along fifteen transects of the length of the slide were examined, compared to the collection of reference preparations, and identified. In a series of observations on subsamples of pellets, it was determined that after five slides from the same pellet, very few new species were recognised. Subsequently, therefore, the list of species from a single pellet was determined from five subsample slides.

Field Collections

Faeces were collected in areas of the two understorey communities and from adjacent pastures where kangaroos were observed. Faecal samples were obtained on April 4 and May 15, 1979. Two additional sets of samples were collected from the two native vegetation areas on June 6 and June 25, 1979. On May 21st, 25 mm of rain fell at the Experimental Station. This rainfall was followed by another 15 mm in the six days to the end of the month. These rains provided the first effective growing period of the season and produced good growth of annuals in the pastures and areas around the granite outcrops of the *Stypandra-Glischrocaryon* community. Faecal samples were not collected on the last two dates from the pasture areas because of the thick regrowth of the pasture grasses. Only recently deposited faeces were collected during each sampling. This was achieved by noting that newly deposited material had a shiny mucus layer. The shiny appearance was lost within one week. Faecal pellets were collected by traversing the sites systematically. From each deposit of faeces, two pellets were taken for analysis. The remaining faeces were removed and kept separately to ensure that duplication of sampling did not occur. However, this collection method did not necessarily avoid sampling more than once from the same kangaroo. The number of faecal pellets collected in the field samples ranged from 26 to 42 pellets. Samples returned from the field sites were oven-dried at 80°C for 24 h and stored at room temperature until analysis.

Field Grazing Observations

During the course of the study a list of plants which appeared to be grazed by the larger herbivores was compiled. These were easily distinguished from those grazed by insects but it was not possible to differentiate between the grazing of grey kangaroo, brush wallaby and rabbits, the only large herbivores in the area. There were 32 taxa of native plants observed to be grazed in the areas of native bush (Table 2). The herbaceous perennials and annuals which appeared after the rains were often heavily grazed, especially around the granite outcrops of the *Stypandra-Glischrocaryon* area.

Species Recorded from Faecal Pellets

Thirty-one species of native plants were recorded from grey-kangaroo faeces collected at Yalanbee (Fig. 2). The exotic grasses *Bromus rubens, B. rigidus, Avena sativa* and *Triticum* sp. constituted the group referred to as "pasture grasses". These grasses were not easily separated by their epidermal patterns and to avoid misidentification, no attempt was made to distinguish between the species in the faecal samples. Other plants of the pasture area, which included several species each of *Lupinus* and *Trifolium*, and *Arctotheca calendula*, were not found in the faecal collections. Of the natives, the most commonly identified species was *Conostylis setigera*, a tufted perennial monocotyledon, occurring in 60% of all pellets analysed during the survey. *Opercularia vaginata* and *Bossiaea eriocarpa* occurred in over 40% of pellets analysed. *Adenanthos cygnorum*, and two taxa which were difficult to separate, a *Hakea* sp. and *Casuarina* sp, were also frequently observed in the faecal samples. Of the species observed in the faeces, 29% were monocotyledons and the remaining 71% were dicotyledons. When compared to 22% monocotyledon—78% dicotyledon percentages for the field sample ratio, it appears the grey kangaroo show some favour for the monocotyledons but further study needs to be done to verify this possibility.

When the data from the summer collections from the different understorey communities were compared there were some notable differences, (Fig. 2). *Acacia celastrifolia*, a plant restricted to the *Hibbertia-Lepidosperma* community, was common in the samples from this area and absent from the *Stypandra-Glischrocaryon* region. *Acacia celastrifolia* was also found in faecal pellets collected in the pasture areas adjacent to the *Hibbertia-Lepidosperma* region. *Calothamnus sanguineus, Adenanthos cygnorum* and the grouping of the several *Hakea* species were identified from all the collection areas but were more frequent in the faecal samples from the *Hibbertia-Lepidosperma* zone and the pasture areas. The pasture grasses and *Conostylis setigera* were common in the faecal collections from all sites. *Opercularia vaginata* and *Bossiaea eriocarpa* were very common in the two native vegetation sites, but were less frequent in the samples from the pasture.

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Table 2

Species of the native woodland showing signs of grazing by large herbivores and confirmed in faecal pellet analyses. Asterisk (*) denotes those species grazed after the first effective rains. See Table 1 for abbreviations.

Species	Order	Family	Life form	Grazed	Faeces
Acacia celastrifolia	D	Leguminosae	S	....	X
Adenanthos cygnorum	D	Proteaceae	S	X	X
Anthocercis littorea	D	Solanaceae	S	X	
Bossiaea eriocarpa	D	Leguminosae	S	X	X
*Burchardia multiflora**	M	Liliaceae	H	X	
Calothamnus sanguineus	D	Myrtaceae	S	X	X
Casuarina spp.	D	Casuarinaceae	S	....	X
Conostylis setigera	M	Haemodoraceae	H	X	X
Dampiera lavandulacea	D	Goodeniaceae	S	X	X
Daviesia juncea	D	Leguminosae	S	X	X
Daviesea decurrens	D	Leguminosae	S		X
*Dianella revoluta**	M	Liliaceae	H	X	..
Dichopogon sp.*	M	Liliaceae	H	X	
Drosera spp.*	D	Droseraceae	H	X	
Dryandra carduacea	D	Proteaceae	S	X	X
Gastrolobium trilobium	D	Leguminosae	S	X	X
Gastrolobium calycinum	D	Leguminosae	S	X	X
Glischrocaryon aureum	D	Haloragaceae	S	X	X
Gompholobium preissii	D	Leguminosae	S	....	X
Gyrostemon subnudus	D	Phytolacaceae	S	X	..
Hakea ambigua	D	Proteaceae	S		X
Hakea trifurcata	D	Proteaceae	S	X	X
Hakea undulata	D	Proteaceae	S	...	X
Jacksonia restioides	D	Leguminosae	S	X	X
Lasiopetalum molle	D	Steruliaceae	S	X	
Lepidosperma scabrum	M	Cyperaceae	H	X	X
Lomandra effusa	M	Liliaceae	H	X	X
Lomandra hermaphrodita	M	Liliaceae	H	X	X
Loxocarya flexuosa	M	Restionaceae	H	...	X
Mirbelia ramulosa	D	Leguminosae	S	X	X
*Neurachne alopecuroidea**	M	Poaceae	H	X	X
Native grasses (not flowering)*	M	Poaceae	H	X	..
Opercularia vaginata	D	Rubiaceae	H	X	X
Petrophile serruriae	D	Proteaceae	S	X	....
Stylidium affine	D	Stylideaceae	H	X	
Stypandra imbricata	M	Liliaceae	H	X	X
Tetraria octandra	M	Cyperaceae	H	X	....
Tetratheca confertifolia	D	Tremandraceae	S	X	....
Tribonanthes uniflora	M	Haemodoraceae	H	X	....
Xanthorrhoea preissii	M	Liliaceae	S	....	X

Change in the frequency of plant species present in the faeces following the onset of winter rains were apparent, despite the relatively small sample (Fig. 3). The percentage of pellets containing pasture grasses was higher following the initial winter rains and the consequently greater availability of the pasture grasses. *Conostylis setigera* remained a common constituent in the diet both before and after the beginning of the winter growing season. The frequency of occurrence of *Opercularia vaginata*, *Bossiaea eriocarpa* and *Casuarina* spp. decreased in the winter samples when compared to the pre-rainfall collections. *Gompholobium preissii* and *Phyllanthus calycinus* were only recorded in faecal samples collected during winter. Also, there was a drop from 24 taxa in the pellets sampled from collections before the rains, to 13 in the samples following the first rains.

Diet Preferences

Information on diet preference can be developed when the field frequency of a plant species in the native communities is compared to the frequency of occurrence in the samples of the diet. An index of diet preference was calculated using the frequency percentage of a species from all native understorey field samples combined divided by the frequency of occurrence of the species from all faecal pellets analysed. The resulting data was then somewhat subjectively classified into species which were 1) highly preferred, ratio > 3.00; 2) moderately preferred, ratio 2.00-3.00; 3) of low preference, ratio 1.00-2.00; and 4) of rare occurrence in diet, ratio < 1.00. It is apparent that the pasture grasses are an important component in the diet of the grey kangaroo at the Yalanbee Experimental Station, even though the animals must leave their resting areas to graze (Table 3). Of the native species, *Adenanthos cygnorum*, *Casuarina* spp. and *Opercularia vaginata* received the highest diet preference ratios. Other preferred native species were *Acacia celastrifolia*, *Hakea* spp., *Gastrolobium trilobium*, *Bossiaea eriocarpa* and *Calothamnus sanguineus*. *Conostylis setigera* was the most frequently encountered species in the faecal pellets. Its frequent field presence resulted in a rating subjectively placing it with moderately preferred species.

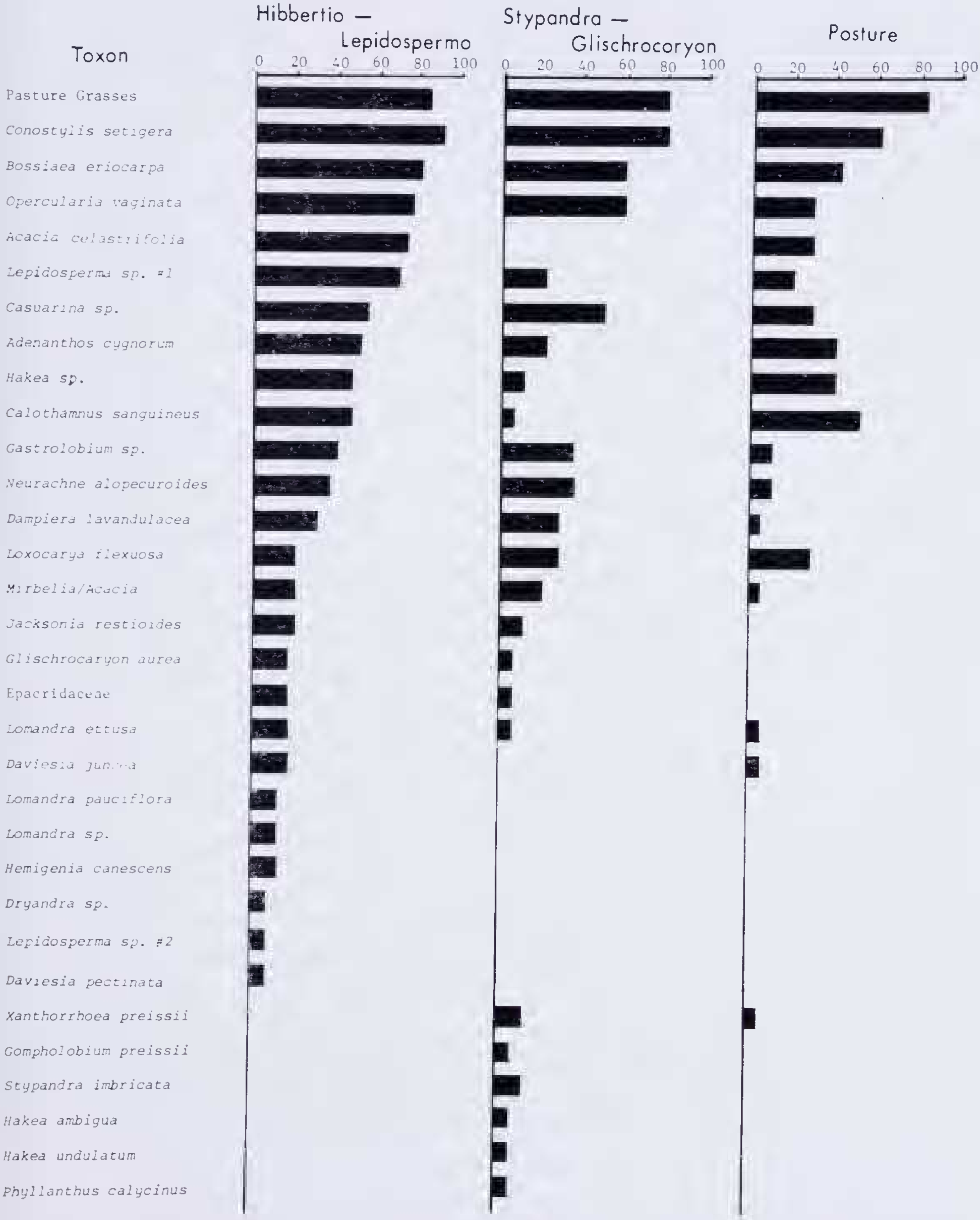

Figure 2.—Collection site variation in the diet of the grey kangaroo. Frequency of occurrence of plant species in faecal pellets collected in sites of pasture, the *Hibbertia-Lepidosperma* understorey community and the *Stypandra-Glischrocaryon* under- standard surveyor's measure.

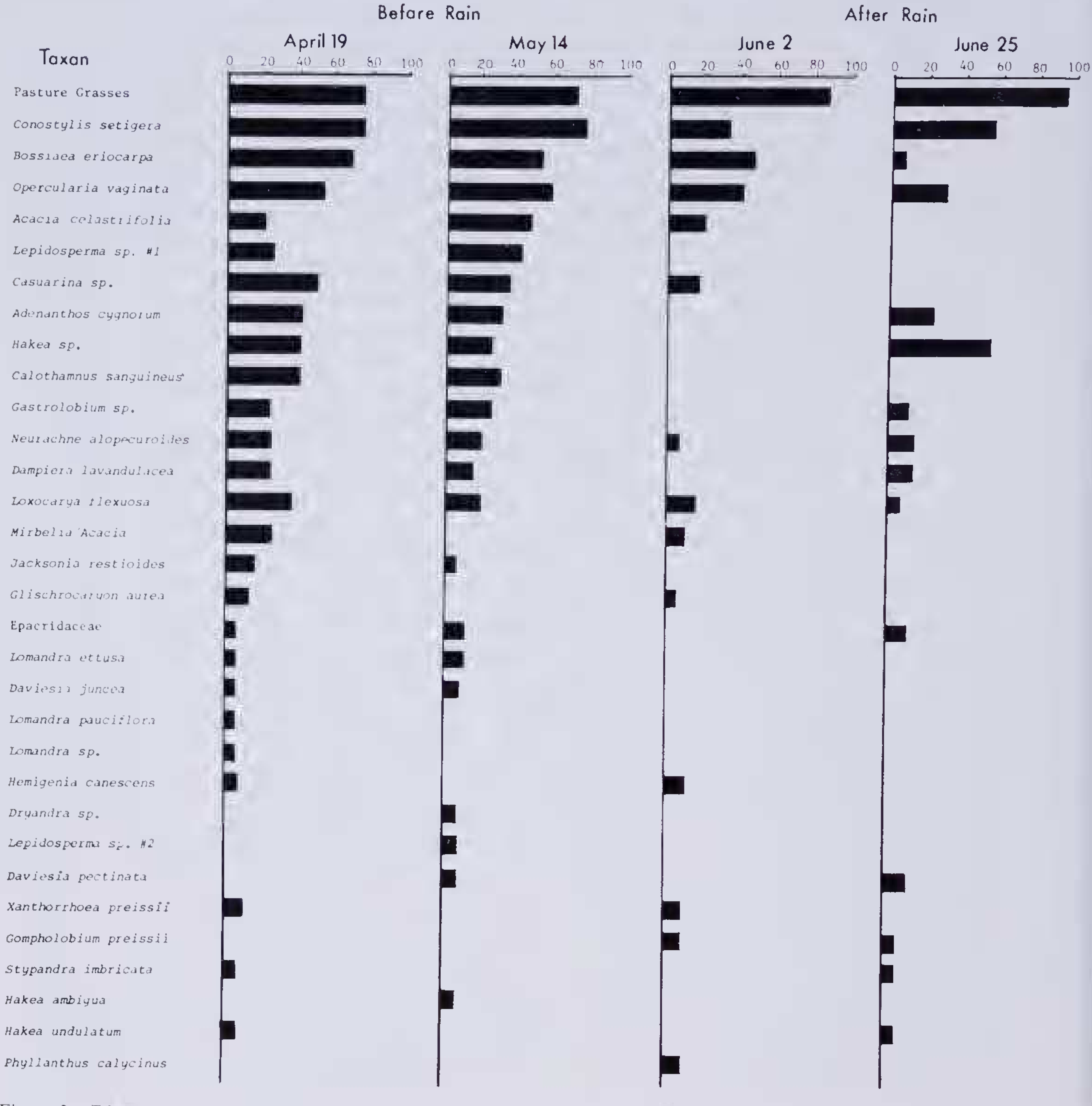

Figure 3.—Diet constituents of the grey kangaroo. Frequency of occurrence in faecal pellets collected on April 19 and May 14, 1979 before significant rainfall, and June 2 and June 25 during the period of good vegetational condition. Data from all collection sites were grouped.

Discussion

Grey kangaroos, like most large herbivores, consume a broad spectrum of plant species representing a range of plant life forms. The grey kangaroo in the native woodland-pasture landscape of the Yalanbee Experimental Station are consuming a mixture of native species in addition to the grasses of the pasture areas. A large number of native dicotyledons occur in the diet of the grey kangaroo in this study. Previous studies of the food habits of large macropods show they are predominantly grazers, with grasses the most important part of the diet. The eastern grey kangaroo was observed by Kirkpatrick (1965) to graze on native grasses and introduced pasture grasses in southern Queensland. Griffiths and Barker (1966) and Griffiths *et al.* (1974) also observed that most of the grazing of the eastern grey kangaroo was confined to the pasture grasses and that dicotyledons represented only a very small part of the diet. These studies, however, were carried out in open grasslands where the dicotyledons are only minor components.

Table 3

Diet preferences of western grey kangaroo at the Yalanbee Experimental Station determined as a ratio of the diet frequence and the field frequency. For diet preference categories, see text.

Species	Diet Frequency	Field Frequency	Preference Ratio	Diet Preference
Pasture Grasses	82·5	0·0	∞	High
Adenanthos cygnorum	28·2	2·4	11·8	High
Casuarina spp.*	27·5	3·8	7·2	High
Opercularia vaginata	43·8	6·2	7·1	High
Acacia celastrifolia	22·5	3·8	5·9	High
Hakea spp.*	32·5	7·8	4·2	High
Gastrolobium trilobium	18·8	4·5	4·1	High
Bossiaea eriocarpa	46·2	11·8	3·9	High
Calothamnus sanguineus	21·2	6·2	3·4	High
Daviesia juncea	3·8	1·5	2·5	Moderate
Dampiera lavandulacea	16·2	6·7	2·4	Moderate
Conostylis setigera	60·2	28·8	2·1	Moderate
Epacridaceae*	6·2	3·0	2·0	Moderate
Lepidosperma spp.*	18·8	11·7	1·6	Low
Daviesia decurrens	2·5	1·6	1·5	Low
Mirbelia/Acacia	10·0	8·0	1·2	Low
Loxocarya flexuosa	21·2	17·5	1·2	Low
Xanthorrhoea preissii	5·0	4·5	1·1	Low
Gompholobium preissii	3·8	4·3	0·9	Rare
Jacksonia restioides	7·5	12·5	0·6	Rare
Glischrocaryon aureum	6·2	11·0	0·6	Rare
Dryandra spp.*	12·5	4·4	0·6	Rare
Hakea undulatua	2·5	5·0	0·5	Rare
Lomandra spp.*	3·0	6·7	0·4	Rare
Hakea ambigua	1·2	3·0	0·4	Rare
Hemigenia canescens	3·8	12·5	0·3	Rare
Stypandra imbricata	2·5	9·5	0·3	Rare
Phyllanthus calycinus	2·5	17·3	0·1	Rare

* Field frequencies of several species combined.

Studies on the yellow-footed rock wallaby in western New South Wales in rock outcrop areas, however, revealed that the dicotyledonous species were the dominant group in the diet of these animals (Dawson and Ellis 1979). In good vegetational conditions the largest component of the diet was composed of the small herbaceous ephemeral forbs. During drought conditions, the monocotyledons became a more important dietary component.

In our study, the proportion of monocotyledons to dicotyledons in the diet was nearly equal to the proportions in the habitat, although the preferences here also seem to make the monocotyledons slightly more favoured in the diets than in field sample values. It is apparent, however, that the western grey kangaroo in the Yalambee region is more of a browser than its eastern counterparts because a large percentage of the shrubby dicotyledons are included as dietary constituents.

Notable among the dicotyledons consumed were the legumes, *Bossiaea eriocarpa, Acacia celastrifolia, Gastrolobium* sp., *Mirbelia/Acacia, Jacksonia restioides, Daviesia juncea,* and *Gompholobium preissii. Casuarina* sp., also a species known to have symbiotic nitrogen fixation capacity, was also common in the dietary components. Although the nitrogen levels of the leaves of these taxa were not analyzed in this study, the hypothesis that the kangaroo may be showing a preference to these species because of the added nitrogen content is a strong possibility. Other constitutents of actively growing plants such as Ca, P, K and moisture may also influence kangaroo preference.

Also notable, although not major components of the diet, were *Gastrolobium* spp., *Stypandra imbricata* and *Glischrocaryon aureum,* three species known to poison domestic stock (Gardner and Bennett 1956). The western grey kangaroo and other native mammals from the south-west of Western Australia have the ability to detoxify the secondary plant compounds found in species of *Gastrolobium* and *Oxylobium* (Oliver *et al.* 1977). It would not be surprising, therefore, to discover the western grey kangaroos also have the ability to tolerate the toxins produced by *Stypandra imbricata* and *Glischrocaryon aureum.*

The diet of the western grey kangaroo at the Yalanbee Experimental Station had a seasonality related to the greater availability of the pasture grasses following the first winter rains. The pasture grasses, however, were still an important constituent of the diet during the drought period of summer when the amount of edible material on the pasture areas was limited. Although annual species showed signs of grazing in the granite outcrop areas, no fragments of these ephemerals appeared in the faecal sample preparations. This may be because the annuals are only a minor component in the diet and the sampling procedure was not extensive enough to detect these species, or that fragments of these herbaceous species did not survive the digestive system of the kangaroo or the process of preparation of the faeces for analysis.

Although the determination of the reasons for the seasonal change in diet was beyond the scope of the current study, the seasonal switch to a preponderance of pasture plants and other ephemerals may be due to their greater nutritional quality. Storr (1964) observed seasonal fluctuations in the quality of the forage available to the Quokka (*Setonix brachyurus* Quoy and Gaimard) on Rottnest Island with respect to nitrogen. During summer and autumn there was a lower level of nitrogen available in grasses and shrubs compared to winter, when these plants would be actively growing. Ealey and Main (1967) observed that rainfall induced new seasonal growth which was high in nitrogen content.

An interesting point also is why the kangraoo still consumes a relatively large amount of the hard, sclerophyllous vegetation when there appears to be other, seemingly more edible, plant material available. This could be that abrupt changes in diet may have severe effects on the micro-fauna of the pseudo-rumen digestive system (Hume 1978) and the continued consumption of native sclerophylls is for roughage to balance the large quantity of soft ephemerals consumed after the onset of the rainy season.

There was little difference in species composition of the faeces from different sites. Also, there were pasture grasses in the faeces from both native vegetation sites as well as in faeces from the pasture areas. It is apparent that considerable movement of the animals takes place. This is also emphasized by the presence of *Opercularia vaginata* in faecal collections from all areas, despite being nearly restricted to the granite outcrop areas of the north

True quantification of the diet of the grey kangaroo at Yalanbee Experimental Station will require a greater understanding of the effects the kangaroo digestive system has on the plant epidermal tissue. Crocker (1959) emphasises that although survival of the leaf cuticle in the faeces of sheep was related to cuticle thickness, some of the diagnostic characters of the thinnest cuticles were completely obliterated during digestion. Slater and Jones (1971) showed that clover fed to sheep may be undetectable in the faeces. Storr (1961) in his studies of diet of the Quokka found there was a good correlation between the relative portions of native perennial plants fed under confinement conditions and the portions of their relative cuticular area in the faeces, but had difficulty in assessing the effect of the kangaroo digestive system when annual vegetation was used because the epidermis of the annual plants did not survive the preparation technique of boiling acid. Although Prince (1976) provided some information on the digestive efficiency of the western grey kangaroo, further studies are necessary to assess the ability of this species to digest cuticular plant material.

The study reported here using faecal analyses has shown that the western grey kangaroo at the Experiment Station still consume considerable numbers of native species, even though presented with extensive areas of surrounding pasture. Further data will be required before a management programme for the numbers of kangaroo in the population can be contemplated.

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